BASINWIDE ASSESSMENT REPORT

HIWASSEE RIVER

NORTH CAROLINA
DEPARTMENT OF ENVIRONMENT AND
NATURAL RESOURCES
Division of Water Quality
Water Quality Section
Environmental Sciences Branch



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EXECUTIVE SUMMARY

This document presents a water quality assessment of the Hiwassee River basin. Monitoring programs covered within this report include benthic macroinvertebrates, ambient water quality, and aquatic toxicity for the period 1994 - 1999. Studies conducted prior to and including 1994 were previously summarized in NCDEHNR (1996a).

In general, the document is structured such that each subbasin is physically described and an overview of water quality is given at the beginning of each subbasin section. General water quality conditions are presented in an upstream to downstream format. The Hiwassee River subbasins are identified by six digit codes (040501 and 040502), but are often referred to by their last two digits (e.g. Subbasin 01).

The Hiwassee River basin is located in the southwestern corner of North Carolina (Figure 1). The mountainous basin covers approximately 640 mi² in Cherokee and Clay counties. The largest rivers are the Hiwassee River and the Valley River. Many of the streams in the basin are located within the Nantahala National Forest.

Overall, water quality in this basin is excellent because most of the streams drain undisturbed, undeveloped, and protected mountain areas. Much of this water quality information comes from the benthic macroinvertebrate monitoring program. Of the 91 benthos samples collected in the Hiwassee River basin since 1983, 79% of these were given either an Excellent or Good bioclassification.

The Hiwassee River is regulated by the Tennessee Valley Authority (TVA) for the production of hydroelectric power. The river is impounded three times in North Carolina to form Chatuge Lake, Hiwassee Lake, and

Apalachia Lake. Mission Dam located below Chatuge Lake, does not form an impoundment. It operates as a run-of-river hydroelectric project. All three lakes were rated oligotrophic during the summer of 1999.

The Upper Hiwassee River (Subbasin 01)
The largest town in this upper watershed is
Hayesville, and land use is mainly forest and
some agriculture. The Hiwassee River
originates in north Georgia and flows
northward into North Carolina. Here it is

northward into North Carolina. Here it is impounded to form Chatuge Lake. Chatuge Lake was considered mesotrophic in 1994 and oligotrophic in 1999. Shooting Creek, a large tributary of Chatuge Lake, retained the Good benthos rating in 1999 that was found in 1994.

Below Chatuge Lake, the first major tributaries of the Hiwassee River are Tusquitee Creek and Fires Creek. The entire Fires Creek catchment is designated Outstanding Resource Waters and most of the Tusquitee Creek watershed is classified High Quality Waters. Both streams were given an Excellent benthos rating in 1999, as was Big Tuni Creek, a tributary of Tusquitee Creek. All of these streams are primarily in the Nantahala National Forest.

Brasstown Creek, a tributary of the Hiwassee River below Mission Dam, originates in north Georgia. This stream was considered impacted in 1994, when it was given a Fair benthos bioclassification. Possible problems were nonpoint source runoff as it flows along NC 66, effluent from the Young Harris Water Pollution Control Plant in Georgia, or scour from the heavy sediment load instream during the high flows at the time of sampling in 1994. In 1999 the stream received a Good bioclassification, with no major changes in land use, but more normal flows.

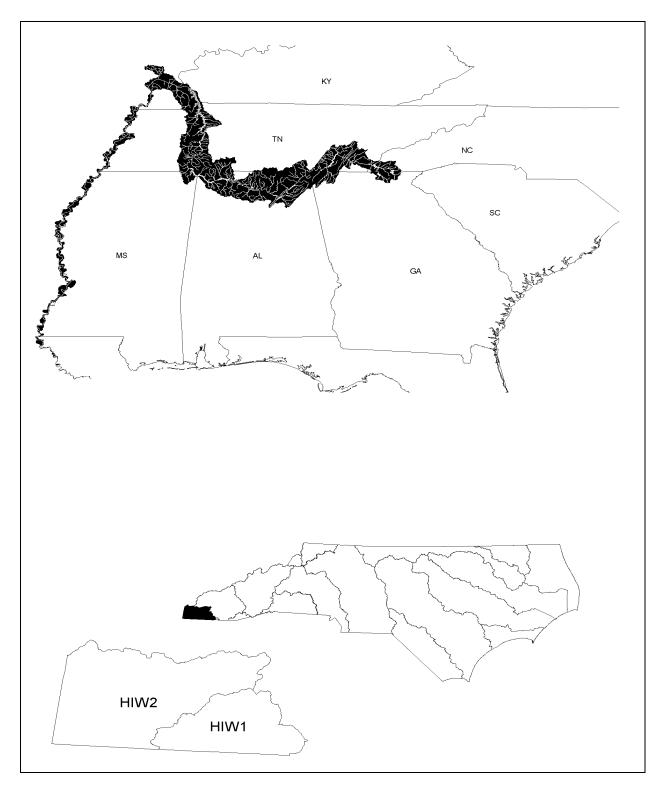


Figure 1. Geographical relationships of the Hiwassee River and its subbasins to the lower Tennessee River and lower Mississippi River drainages.

The Lower Hiwassee River (Subbasin 02)

This subbasin lies entirely within Cherokee County and contains the towns of Murphy and Andrews. Land use here is primarily agricultural and forest, with some urban areas in the Valley River watershed between Andrews and Murphy, along US 19/129. However, most of the watershed is within the Nantahala National Forest.

Ambient water chemistry monitoring data are collected from the Hiwassee River near Murphy and from the Valley River at Tomotla. The Hiwassee River at this site is classified as a water supply. There were very few excursions from water quality reference levels at these sites and most aqueous metal concentrations were less than the reporting levels. Fecal coliform and total coliform bacteria concentrations (indicators of instream human or agricultural wastes) occasionally exceeded the reference value and coincided with elevated turbidity values during high flows. This was especially true at the Hiwassee River site. Overall, however, there has been a decrease in the geometric mean and proportion of fecal coliform samples that exceed reference values. The low pH values noted between 1991 and 1995 were not found in this basin cycle.

Long-term macroinvertebrate data from the Hiwassee River near Murphy indicates generally Good water quality. The stress on this system is largely related to the flow fluctuations caused by the upstream hydroelectric power facilities and by nonpoint source runoff.

The 1999 benthos basin sampling resulted in Excellent bioclassifications for Peachtree Creek, Hanging Dog Creek, Persimmon Creek, Beaverdam Creek and Shuler Creek, all tributaries of the Hiwassee River (or Hiwassee Lake) below Murphy. South Shoal Creek, Junaluska Creek and the Nottely River

received Good ratings. Two changes from the 1994 data were that the Nottely River declined from Excellent to Good, and Shuler Creek improved from Good to Excellent, but both differences were based on small changes in EPT taxa richness and may not represent any real change in water quality. Junaluska Creek's lower benthos rating in 1994 (Good-Fair) may have been a result of scour by sediment during high flows in 1994. TVA biological sampling of streams in this area in 1999 also resulted in all Good or Excellent benthos ratings.

The Valley River is the largest tributary to the Hiwassee River in this subbasin. The Valley River flows in a southwesterly direction through the towns of Topton, Andrews, Marble, and Tomotla to its confluence with the Hiwassee River just below Murphy. The Valley River has remained relatively stable with a Good-Fair rating. Problems noted previously in a section of the Valley River on the impaired streams list, had improved in 1999 when Good-Fair bioclassifications were found. Webb Creek, another stream thought to be impaired was given a Good benthos bioclassification in 1999. Two small tributaries of the Valley River are classified either HQW (Britton Creek) or ORW (Gipp Creek).

Lake sampling of Hiwassee Lake and Apalachia Lake near the North Carolina-Tennessee border indicated oligotrophic conditions in both 1994 and 1999. TVA has a biological monitoring program to evaluate the ecological health of its reservoirs. Both of these reservoirs were rated as Fair in 1998 according to the TVA program.

Whole effluent toxicity testing is required for the Clay County, Andrews and Murphy WWTPs. Since 1993, the compliance rate of facilities required to monitor for toxicity has fluctuated between 90 and 95%.

EXECUTIVE SUMMARIES BY PROGRAM AREA

BENTHIC MACROINVERTEBRATES

Water quality in the Hiwassee River basin, as assessed using benthic macroinvertebrates, is generally Excellent. This is because much of the watershed is within the Nantahala National Forest. Ninety-one samples have been collected since 1983 and 79% of these have rated either Good or Excellent. Since 1994, the water quality has improved slightly (Figure 2).

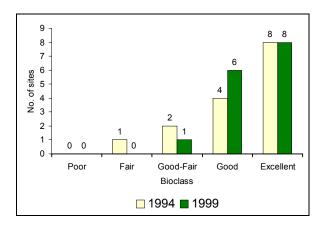


Figure 2. Bioclassifications of the same sites rated in 1994 and 1999 in the Hiwassee River basin. Sample size = 15.

The few water quality problems encountered in this basin are related to nonpoint source runoff. The only streams ever rated as Fair are Brasstown Creek and the Valley River. Brasstown Creek improved to Good in 1999, and the Valley River now maintains a Good-Fair rating. The Valley River catchment is affected by urban runoff from Topton, Marble, Andrews, and Tomotla, and agricultural activity within the watershed.

Flow in the Hiwassee River is completely regulated by the Tennessee Valley Authority for the production of hydroelectric power. The river is impounded three times in North Carolina to form Chatuge Lake, Hiwassee Lake, and Apalachia Lake. The stress on the benthic invertebrate communities in this basin is largely related to the fluctuations in natural flow caused by the use of water for power generation.

FISHERIES

Fish Community Assessment

Sixty-eight species have been collected from the Hiwassee River basin in North Carolina (Menhinick 1991, 1995 (pers. comm.)). Special status has been granted to six of these species by the United States Department of the Interior, the North Carolina Wildlife Resources Commission, or the North Carolina Natural Heritage Program under the North Carolina State Endangered Species Act (G.S. 113-311 to 113-337 (LeGrand and Hall 1999; Menhinick and Braswell 1997) (Table 1). Additional information on these six species may be found in Menhinick and Braswell (1997).

The North Carolina Index of Biotic Integrity is one of the tools the NCDWQ uses which summarizes all classes of factors such as water and habitat quality, flow regime, and energy sources which influence the freshwater fish communities of wadeable streams throughout the state. No stream fish community basinwide monitoring was conducted during 1999 in the Hiwassee River basin because of recent revisions and a reexamination of the criteria and metrics.

Fish Tissue Contaminants

No fish tissue contaminant monitoring was conducted between 1994 and 1999 because of the lack of any significant contaminant issues in the basin.

Table 1. Species of fish listed as endangered, rare, threatened, or of special concern in the Hiwassee River basin in North Carolina.

Species	Common Name	State or Federal Status	State Rank ¹
Cyprinella monacha	Spotfin chub	Federal - Threatened	S1
Noturus flavus	Stonecat	State - Endangered	S1
Clinostomus funduloides ssp.	Hiwassee Rosyside dace (Smoky dace)	State - Special Concern	S2
Etheostoma vulneratum	Wounded darter	State - Special Concern	S2
Notropis lutipinnis	Yellowfin shiner	State - Special Concern	S3
Percina squamata	Olive darter	State - Special Concern	S2

S1 = critically imperiled in North Carolina because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from North Carolina; S2 = imperiled in North Carolina because of rarity or because of some factor(s) making it very vulnerable to extirpation from North Carolina; and S3 = rare or uncommon in North Carolina (LeGrand and Hall 1999).

Fish Kills

The Division has systematically monitored and reported on fish kill events across the state since 1996. Several small kills (less than 25 fish/kill) were observed in Chatuge Lake during the summer of 1998. During this dry and hot period, dissolved oxygen levels were low in the reservoir. A larger kill of approximately 200 fish (of which most were yellow perch, 10-25 cm in length) was observed during this period in the tailrace below the powerhouse. The kill was attributed to low dissolved oxygen levels in the water passing through the turbines. There was also a strong smell of hydrogen sulfide in the tailrace. No other fish kills have been reported during this time period.

Information on fish kills in other basins may be found on the Division's website (refer to the Glossary).

LAKE ASSESSMENT

Three lakes in the basin were sampled as part of the Lake Assessment Program (Table 2). The July 1999 North Carolina Trophic State Index scores classified each of the lakes as oligotrophic (low biological productivity, NCTSI < - 2.0) (Figure 3).

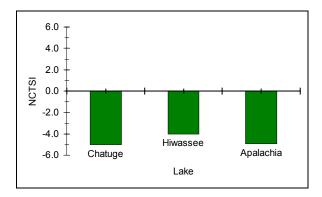


Figure 3. North Carolina Trophic State Index scores for lakes in the Hiwassee River basin, July 1999.

As with other mountain lakes in the state, these reservoirs exhibited very good to excellent water quality. A chlorophyll *a* concentration greater than what had been previously recorded by the Division in Hiwassee Lake was observed in the Nottely River arm in July 1999. Appalachia Lake exhibited a very gradual increase in lakewide mean chlorophyll *a* in July, 1999 as compared with 1981 and 1994.

AMBIENT MONITORING SYSTEM

Ambient water quality monitoring was conducted at two sites in the basin. At both locations, fecal coliform bacteria concentrations have decreased over time. Hydrogen ion concentrations (pH) decreased during the period 1991-1994. The cause(s) were unknown. Atmospheric deposition was speculated but there was also the possibilities of monitoring personnel error and pH meter equipment variability. During this recent monitoring cycle, pH increased to values greater than those observed during the period 1980 - 1991.

Dissolved oxygen concentrations continued to remain above 7.0 mg/l. High turbidity values were often associated with precipitation events. No temporal patterns could be noted for nutrients and concentrations were not considered indicative of water quality problems. Copper concentrations exceeded the action level of 7 μ g/l less than 10% of the time.

AQUATIC TOXICITY MONITORING

Three facilities in the Hiwassee River basin have NPDES permits which require whole effluent toxicity (WET) monitoring. These facilities are Clay County's, Andrews', and Murphy's wastewater treatment plants. Since 1993, all facilities operated within a compliance rate of 90 - 95%.

Table 2.	Lakes monitored in the	Hiwassee River	basin in 1999.

Subbasin/ Lake	County	Classification	Surface Area (Ac)	Mean Depth (ft)	Volume (X 10 ⁶ m ³)	Watershed (mi ²)	Retention Time (days)
01 Chatuge Lake 02	Clay	В	6950	36	305	187	260
Hiwassee Lake Apalachia Lake	Cherokee Cherokee	В, С В, С	6275 1100	154 59	119 8	968 1006	116 12

INTRODUCTION TO PROGRAM METHODS

The Division uses a basinwide approach to water quality management. Activities within the Division, including permitting, monitoring, modeling, nonpoint source assessments, and planning are coordinated and integrated for each of the 17 major river basins within the state. All basins are reassessed every five years, and the Hiwassee River basin was sampled by the Environmental Sciences Branch in 1994 and 1999.

The Environmental Sciences Branch collects a variety of biological, chemical, and physical data that can be used in a myriad of ways within the basinwide planning program. In some areas there may be adequate data from several program areas to allow a fairly comprehensive analysis of ecological integrity or water quality. In other areas, data may be limited to one program area, such as only benthic macroinvertebrate data or only fisheries data, with no other information available. Such data may or may not be adequate to provide a definitive assessment of water quality, but can provide general indications of water quality. The primary program areas from which data were drawn for this assessment of the Hiwassee River basin include benthic macroinvertebrates, lake assessment, ambient monitoring, and aquatic toxicity monitoring.

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates, or benthos, are organisms that live in and on the bottom substrates of rivers and streams. These organisms are primarily aquatic insect larvae. The use of benthos data has proven to be a reliable monitoring tool, as benthic macroinvertebrates are sensitive to subtle changes in water quality. Since many taxa in a community have life cycles of six months to one year, the effects of short term pollution (such as a spill) will generally not be overcome until the following generation appears. The benthic community also integrates the effects of a wide array of potential pollutant mixtures.

Sampling methods and criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample from flowing waters based on the number of taxa present in the intolerant groups Ephemeroptera, Plecoptera and Trichoptera (EPT S) (Appendix B1). Likewise, ratings can be assigned with a North Carolina Biotic Index (BI). This index summarizes tolerance data for all taxa in each collection. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed

as well by a taxa richness analysis. Different criteria have been developed for different ecoregions (mountains, piedmont and coastal) within North Carolina for freshwater flowing waterbodies.

Bioclassifications listed in this report (Appendix B2) may differ from older reports because evaluation criteria have changed since 1983. Originally, total taxa richness and EPT taxa richness criteria were used, then just EPT taxa richness, and now BI as well as EPT taxa richness criteria are used for flowing freshwater sites. Refinements of the criteria continue to occur as more data are gathered.

LAKE ASSESSMENT

Lakes are valued for the multiple benefits they provide to the public, including recreational boating, fishing, drinking water, and aesthetic enjoyment. Assessments have been made at publicly accessible lakes, at lakes which supply domestic drinking water, and lakes (public or private) where water quality problems have been observed.

Physical field measurements (dissolved oxygen, pH, water temperature, and conductivity) are made with a calibrated HydrolabTM. Readings are taken at the surface of the lake (0.15 meters) and at 1 m increments to the bottom of the lake. Secchi depths are measured at each sampling station with a weighted Secchi disk attached to a rope marked off in centimeters. Surface water samples are collected for chloride, hardness, fecal coliform bacteria, and metals. A Labline TM sampler is used to composite water samples within the photic zone (a depth equal to twice the Secchi depth). Nutrients, chlorophyll a, solids, turbidity and phytoplankton are collected at this depth. Nutrients and chlorophyll a from the photic zone are used to calculate the North Carolina Trophic State Index score. The Labline TM sampler is also used to collect a grab water samples near the bottom of the lake for nutrients. Water samples are collected and preserved in accordance with protocols specified in (NCDEHNR 1996b).

Data are used to determine the trophic state of each lake, a relative measure of nutrient enrichment and productivity. These determinations are based on information from the most recent summertime sampling (Appendices L1 - L3).

AMBIENT MONITORING SYSTEM

Assessments of water quality can be obtained from information about the biological communities present in a body of water or from field and laboratory measurements of particular water quality parameters. This section summarizes the field and laboratory measures of water quality, typically referred to as ambient water quality measures.

The Ambient Monitoring System is a network of stream, lake, and estuarine stations strategically located for the collection of physical and chemical water quality data. Parametric coverage is tiered by freshwater or saltwater waterbody classification and corresponding water quality standards. Under this arrangement, core parameters are based on Class C waters with additional parameters appended when justified (Table 3).

Summaries of water quality parameters measured during the five year period (September 1, 1994 – August 31, 1999) are provided (refer to Tables 16 and 17). These tables present the number of samples collected and the number (and proportion) of samples greater than or less than a water quality reference value. In addition, a description of how the data are distributed is provided using percentiles. Percentiles describe the proportion of observations less than a specific value or concentration. For example, the 50th percentile (also called the median) provides the value (or concentration) of the parameter in which one half (50%) of the observations lie.

The water quality reference value may be a narrative or numeric standard, or an action level as specified in the North Carolina Administrative Code 15A NCAC 2B .0200. Zinc is not included in the summaries for metals because recent (since April 1995) sampling or analyses may have been contaminated with zinc and the data may be unreliable.

In this report, conductivity is synonymous with specific conductance. It is given in micromhos per centimeter (µmhos/cm) at 25 °C.

AQUATIC TOXICITY MONITORING

Acute and/or chronic toxicity tests are used to determine toxicity of discharges to sensitive aquatic species (usually fathead minnows or the water flea, Ceriodaphnia dubia). Results of these tests have been shown by several researchers to be predictive of discharge effects on receiving stream populations.

Table 3. Freshwater parametric coverage for the ambient monitoring system.1

_	All	Water
Parameter	freshwater	Supply
Field		
Dissolved oxygen	X	Х
рН	X	Х
Conductivity	✓	~
Temperature	✓	✓
Nutrients		
Total phosphorus	✓	~
Ammonia as N	✓	~
Total Kjeldahl as N	✓	~
Nitrate + nitrite as N	✓	х
Other		
Total suspended solids	✓	
Total dissolved solids		Х
Turbidity	X	X
Hardness	✓	Х
Chloride	✓	X
Bacteria		
Fecal coliform bacteria	Χ	Х
Total coliform bacteria		Х
Metals		
Aluminum	✓	~
Arsenic	X	Х
Cadmium	X	Х
Chromium	X	Х
Copper	X	Х
Iron	X	Х
Lead	X	Х
Mercury	X	X
Nickel	X	Х
Silver	X	X
Zinc	X	Х
Manganese		Х
Biological		
Chlorophyll a ²	Х	х

A check () indicates the parameter is collected; an 'x' indicates the parameter is collected and has a standard or action level. ²Chlorophyll *a* is collected in Nutrient Sensitive Waters (NSW).

Many facilities are required to monitor whole effluent toxicity by their NPDES permit or by administrative letter. Facilities without monitoring requirements may have their effluents evaluated for toxicity by the Division's Aquatic Toxicology Laboratory. If toxicity is detected, the Division may include aquatic toxicity testing upon permit renewal.

The Aquatic Toxicology Unit maintains a compliance summary for all facilities required to perform tests and provides a monthly update of this information to regional offices and Division administration. Ambient toxicity tests can be used to evaluate stream water quality relative to other stream sites and/or a point source discharge.

HIWASSEE RIVER SUBBASIN 01

Description

This subbasin lies entirely within Clay County (Figure 4). The Hiwassee River originates in north Georgia and flows northward into North Carolina, where it is dammed to form Chatuge Lake. This is the first in a series of four dams before the river reaches the Tennessee state line. All these, except Mission Dam, form large impoundments. Major tributaries to the Hiwassee River in this subbasin include Shooting Creek, Tusquitee

Creek, Fires Creek and Brasstown Creek (which also originates in Georgia). The largest town in this subbasin is Hayesville. Land use within this subbasin is mainly forested with some agriculture. There are two NPDES permitted dischargers in this subbasin; the largest is Clay County's wastewater treatment plant with a permitted flow of 0.3 MGD.

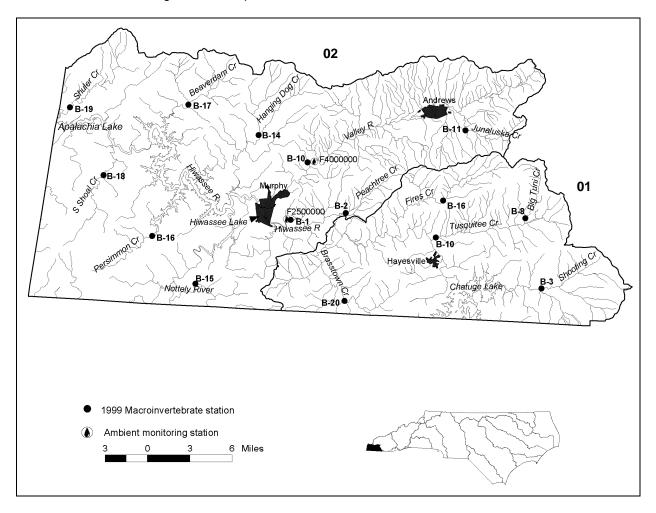


Figure 4. Sampling sites in Subbasins 01 and 02 in the Hiwassee River basin.

Overview of water quality

Twenty sites (51 benthic invertebrate collections) have been sampled in this subbasin since 1985. Two of the sites sampled in 1999 (Fires Creek and Big Tuni Creek) have long-term data. Both site have continued to receive Excellent ratings based on the benthic macroinvertebrate data. Overall water quality in this subbasin is Excellent, as most of the streams drain undisturbed and protected watersheds. The entire Fires Creek catchment has been designated as an ORW and most of the Tusquitee Creek watershed is classified as HQW.

Brasstown Creek, one of the five sites sampled in this subbasin in both 1994 and 1999, showed an improvement in water quality (Table 4). The other four sites continued to be rated Good or Excellent. The few water quality problems encountered in this subbasin are related to nonpoint source runoff.

The only site sampled in this subbasin ever to receive a rating less than Good was Brasstown Creek at SR 1104. This creek originates in north Georgia and flows along NC 66 for most of its length. It also receives effluent from the Young

Harris Water Pollution Control Plant in Georgia. This site showed an improvement in water quality between 1994 (Fair) and 1999 (Good). The degradation found in 1994 may be related to the high flows that year which increased nonpoint source impacts and also caused sampling difficulties.

Some small fish kills were observed in Chatuge Lake in 1998 when dissolved oxygen concentrations were low in the reservoir. A larger kill (approximately 200 fish) was also observed during this hot dry period in the tailrace below the powerhouse. This kill was attributed to low oxygen levels, as well. Chatuge Lake was sampled in 1998 and 1999 as part of the Lake Assessment Program, and was classified as oligotrophic.

The Clay County WWTP, the only facility in this subbasin that is required to perform whole effluent toxicity testing, has been in compliance during this assessment cycle.

River and Stream Assessment

Shooting Creek, SR 1340

Shooting Creek is a large tributary to Chatuge Lake. At this site, it has a drainage area of 39 mi² and follows US 64 for most of its length. The stream at this site, which is in the middle section of the watershed, is seven meters wide. The bottom substrate showed evidence of sedimentation (pools filled in with sand and silt). Land use in this catchment is mostly agriculture. This site retained its Good bioclassification in 1999.

Big Tuni Creek, SR 1311

This downstream site on Big Tuni Creek has been sampled three times since 1989, always resulting in an Excellent bioclassification. This site has also consistently supported a diverse intolerant fauna

including: Serratella carolina and several species of Drunella, Ephemerella, and Rhyacophila.

Tusquitee Creek, SR 1300

Tusquitee Creek had been previously sampled four times at a more upstream location (SR 1330). In 1999, the assessment site was moved to SR 1300, a more downstream location. Here, the stream is 13 m wide with a predominately rubble substrate with some boulders.

Despite an increase in development in this watershed, the stream continued to be rated Excellent, based on the benthic macroinvertebrate community.

Table 4. Waterbodies monitored in Subbasin 01 in the Hiwassee River basin for basinwide assessment, 1994 - 1999.

Map # ¹	Waterbody	County	Location	1994	1999
3-3	Shooting Cr	Clay	SR 1340	Good	Good
3-8 ²	Big Tuni Cr	Clay	SR 1311	Excellent	Excellent
3-10 ²	Tusquitee Cr	Clay	SR 1300		Excellent
3-16 ²	Fires Cr	Clay	SR 1330	Good	Excellent
3-20	Brasstown Cr	Clay	SR 1104	Fair	Good
	Chatuge Lake	Clav		Mesotrophic	Oligotrophic

B = benthic macroinvertebrate monitoring sites.

²Data are available prior to 1994, refer to Appendix B2.

Fires Creek, SR 1330

This site, at a picnic area, supports an abundance of intolerant species and has consistently been given an Excellent bioclassification, except in 1994 when high flows scoured the substrate and resulted in a Good rating. Historically, over 100 different EPT taxa have been collected from this location since 1985.

Fires Creek is a pristine mountain stream, which supports populations of several unusual animal species, such as the water shrew, the blackbelly salamander, and the hellbender (Biological Assessment Unit Memorandum B-880906). Fires Creek is supplementally classified as ORW.

Brasstown Creek, SR 1104

Brasstown Creek at SR 1104 in Clay County improved from a Fair bioclassification in 1994 to Good in 1999. The substrate at this site is primarily bedrock. There were no good kickable riffle areas and there was a tremendous amount of sand in the stream. The instream habitat at this site remains sparse and the stream channel at this location is heavily sedimented. However, the macroinvertebrates showed a marked improvement since 1994. EPT taxa richness increased from 18 in 1994 to 44 in 1999. EPT abundance also showed a marked increase as well

(from 60 to 175). In 1994, the flows were substantially higher, making this normally difficult to sample site even more difficult. This may explain some of the differences between the two sampling periods.

SPECIAL STUDIES

During March 1999, TVA biologists collected information on fish, benthic invertebrates, and habitat characteristics at six sites in this subbasin (unpublished data) (Table 5). The macroinvertebrate data were limited to the number of EPT families with a maximum score of about 25 families/site. The habitat assessment score had a maximum value of 52.

The Town Creek and Little Brasstown Creek watersheds have been targeted by the Division's Nonpoint Source Team to address rural nonpoint source pollution impacts to these streams.

Town Creek, with a 1.1 mi² drainage area, is too small to rate using current Division benthos criteria. The stream was impacted by the Hayesville WWTP (NCDEHNR 1997a). The Town Creek WWTP is now owned by Clay County and no longer discharges to Town Creek. The new facility with a design flow of 0.3 MGD now discharges to the Hiwassee River.

Table 5. Biological and habitat data collected by the Tennessee Valley Authority from Subbasin 01 in the Hiwassee River basin, March, 1999. Note: EPT ratings are not equivalent to Division ratings.

			No. of EPT	EPT	No. of Fish	No. of	TVA	Habitat
Stream	Location	County	Families	Rating	Species	Fish	IBI	Score
Blair Cr	SR 1140	Clay	19	Good	10	114	32	25
Fires Cr	SR 1300	Clay	21	Good	9	287	34	49
Hyatt Mill	SR 1140	Clay	22	Good	8	501	42	26
Qually Cr	SR 1306	Clay	20	Good	7	307	46	36
Town Cr	Off SR 1140	Clay	4	Poor	3	79	24	21
Tusquitee Cr	Off SR 1300	Clay	19	Good	10	737	36	42

Lake Assessment

Chatuge Lake

Chatuge Lake straddles the North Carolina-Georgia state line (Figure 5). The lake is adjacent to the Nantahala National Forest and is an impounded section of the Hiwassee River upstream of Hiwassee Lake and Apalachia Lake.

Chatuge Lake, owned by the TVA, provides hydroelectric power, flood control, and recreation opportunities. Major tributaries to the lake include the Hiwassee River and Shooting Creek.

Chatuge Lake was most recently sampled in June and July, 1999 (Table 6 and Appendices L2 and L3). Secchi depths ranged from 2.8 m in June to 4.8 m in July. Total phosphorus and nitrite+nitrate concentrations were less than the detection levels (0.01 mg/l). Chlorophyll *a* concentrations were also low (< 10 μ g/l). Based on calculated NCTSI scores, Chatuge Lake was oligotrophic in June and July.

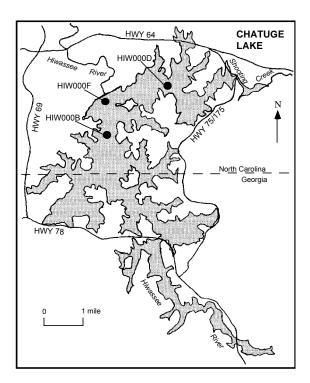


Figure 5. Monitoring sites at Chatuge Lake, Clay County.

Data collected from 1981 through 1999 for the four constituents of the NCTSI were summarized using box and whisker plots (Figure 6). Median Secchi depth and total phosphorus and chlorophyll *a* concentrations have been consistent among the three monitoring sites over time, The median total

organic nitrogen concentration at the mid-lake sampling site (HIW000B) was less than the other two sites.

There were two or three small fish kills (< 25 fish/kill) in Chatuge Lake in 1998 (Donald Anderson, TVA, pers. comm.). These kills may have been caused by the combination of a long, hot summer and low dissolved oxygen levels in the lake. Also in 1998, the lake had decreased water clarity because of algal blooms and there were complaints of hydrogen sulfide odors in the water downstream of the powerhouse.

There has been recent rapid and heavy residential development within the lake's watershed. Public interest in this lake is at a high level and new citizen groups have formed to address concerns related to the lake's water quality (Donald Anderson, TVA, pers. com).

In 1990, the TVA began a program to monitor the biological conditions of its reservoirs. The purpose of this program is to provide information on the integrity or "health" of the aquatic ecosystems of the reservoirs. The TVA rating system, which is not comparable to the rating method used by the Division, is based on the assignment of a numerical score which is then used to define each of five reservoir indicators as Poor, Fair, or Good.

In 1997 according to the TVA program, the lake was rated as Good. However, in 1998, the overall ecological health of Chatuge Lake was rated as Poor (Dycus, et al. 1999). Three of the five indicators (sediment quality, dissolved oxygen, and fish assemblage) were rated as Poor at both the forebay and at the Shooting Creek sampling sites. Benthic invertebrate samples from the Shooting Creek Arm were rated as Good. Chlorophyll concentrations, considered relatively high for a lake in the Blue Ridge ecoregion, were rated as Fair. Reports of fish kills and of "rotten egg" odors in the tailwater indicated poor water conditions.

A reaeration weir has been constructed by the TVA to improve dissolved oxygen concentrations in the tailwaters downstream of the powerhouse. However, hydrogen sulfide odors in the tailwaters continued to be reported during the summer months. The anoxic and hydrogen sulfide-rich waters are of hypolimnetic origin in Chatuge Lake during the summer months.

Table 6. Biological and water chemistry data from Chatuge Lake, 1994 - 1999.

Date	NCTSI	Rating	TP (mg/l)	TON (mg/l)	CHL a (µg/l)	Secchi (m)
07/06/1999	-5.0	Oligotrophic	< 0.01	0.14	6	3.5
06/21/1999	-5.2	Oligotrophic	< 0.01	0.12	5	3.0
08/31/1994	-1.3	Mesotrophic	0.05	0.36	1	1.7

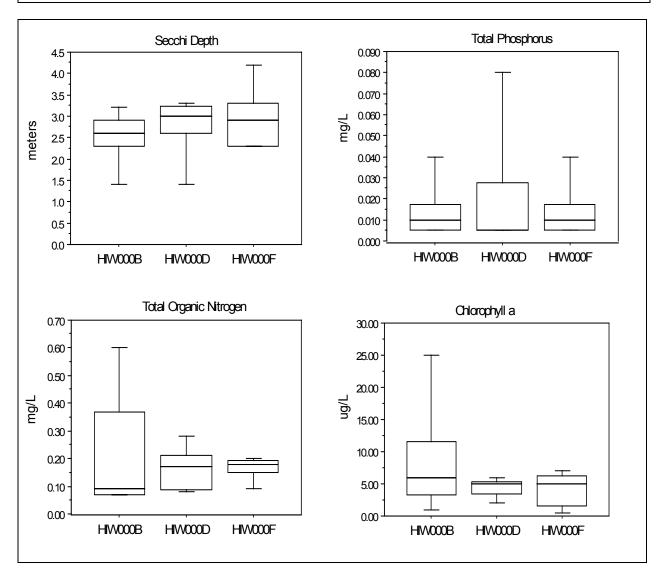


Figure 6. Spatial relationships among limnological data from Chatuge Lake, 1981 – 1999 (n = 5).

HIWASSEE RIVER SUBBASIN 02

Description

Hiwassee River subbasin 02 lies entirely within Cherokee County (Figure 7). It contains the portion of the Hiwassee River from the Cherokee/Clay County line to the Tennessee border. Most of the river's drainage in this subbasin is located within the Nantahala National Forest. Also, most of the river is impounded to form Hiwassee Lake and Apalachia Lake. The Tennessee Valley Authority (TVA) regulates water releases from these lakes for the production of hydroelectric power.

The Valley River is the largest tributary to the Hiwassee River. The river flows in a southwesterly direction through the towns of Topton, Andrews, Marble, and Tomotla to its confluence with the Hiwassee River just below Murphy. Land use in this subbasin is primarily agricultural and forest. There are some urban areas between Andrews and Murphy along US 19/129. There are seven permitted dischargers in this subbasin. The largest is the Town of Andrews' wastewater treatment plant which discharges 1.5 MGD into the Valley River.

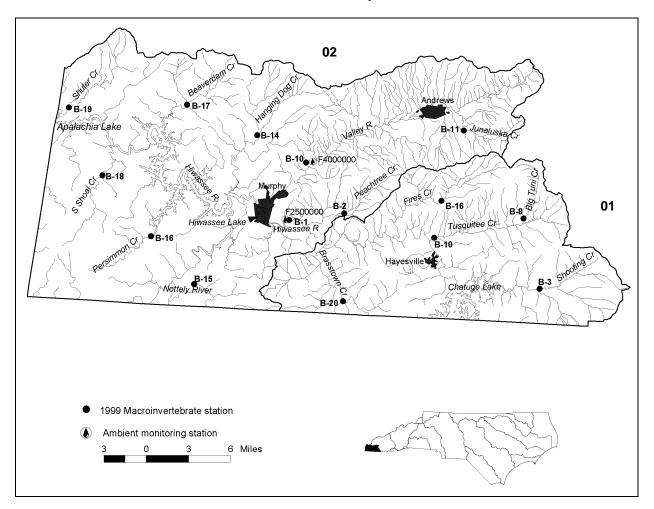


Figure 7. Sampling sites in Subbasins 01 and 02 in the Hiwassee River basin.

Overview of water quality

Nineteen sites (40 benthic invertebrate collections) have been sampled in this subbasin since 1983. The 1999 basin sampling resulted in Excellent bioclassifications for five locations (Table 7). South Shoal Creek, Junaluska Creek and the Nottely River received Good ratings. The Nottely River declined in rating and Shuler Creek improved by one bioclass since last sampled in 1994. The Valley River near Tomotla and the Hiwassee River in Murphy are two sites in this subbasin with long-term data. The Valley River has remained relatively stable with a Good-Fair rating and the Hiwassee River continued to be rated Good.

Hiwassee Lake and Apalachia Lake were sampled in 1999, as part of the Lake Assessment Program, and were classified as oligotrophic. There have been no reported fish kills, algal blooms, or problems with aquatic plants in these lakes.

There are two ambient monitoring stations in the Hiwassee River basin and both are in this subbasin. They are the Hiwassee River above Murphy and the Valley River at Tomotla. There have been few water quality concerns at either the Hiwassee River above Murphy or the Valley River at Tomato, except for an increase in pH values noted since 1994. This trend was also noted in the Little Tennessee River and Savannah River basins.

The WWTPs for the towns of Andrews and Murphy are the only facilities in this subbasin that are required to perform whole effluent toxicity testing. Both facilities were in compliance during this basin assessment cycle.

Table 7. Waterbodies monitored in Subbasin 02 in the Hiwassee River basin for basinwide assessment, 1994 - 1999.

Map # ¹	Waterbody	County	Location	1994	1999
B-1 ²	Hiwassee R	Cherokee	US 64		Good
B-2	Peachtree Cr	Cherokee	SR 1537	Excellent	Excellent
B-10 ²	Valley R	Cherokee	SR 1555	Good-Fair	Good-Fair
B-11	Junaluska Cr	Cherokee	SR 1505	Good-Fair	Good
B-14	Hanging Dog Cr	Cherokee	SE 1331	Excellent	Excellent
B-15	Nottely R	Cherokee	SR 1596	Excellent	Good
B-16	Persimmon Cr	Cherokee	SR 1127	Excellent	Excellent
B-17	Beaverdam Cr	Cherokee	SR 1326	Excellent	Excellent
B-18	South Shoal Cr	Cherokee	SR 1314	Good	Good
B-19	Shuler Cr	Cherokee	SR 1323	Good	Excellent
	Hiwassee Lake	Cherokee		Oligotrophic	Oligotrophic
	Apalachia Lake	Cherokee		Oligotrophic	Oligotrophic

¹B = benthic macroinvertebrate monitoring sites.

²Data are available prior to 1994, refer to Appendix B2.

River and Stream Assessment

Hiwassee River, US 64

This portion of the Hiwassee River near Murphy may be stressed by flow fluctuations caused by the upstream hydroelectric power plants and by sediment from nonpoint runoff. Taxa richness and EPT taxa richness have increased since an initial survey in 1983, and there has been an overall decrease in the Biotic Index, but this site maintains a rating of Good (Table 8 and Figure 8). This site was not sampled in 1994 due to very high flow conditions. The Hiwassee River at Murphy also is an ambient monitoring location.

Table 8. Flows and bioclassifications for the Hiwassee River, US 64, Cherokee County.

Year	Flow	Rating
1983	Normal	Good-Fair
1984	High	Good
1985	Low-Normal	Good
1986	Low	Good-Fair
1987	Low	Good
1990	High	Good
1994	High	No sample
1999	Normal	Good

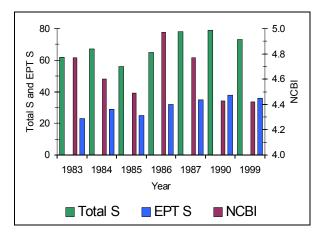


Figure 8. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for the Hiwassee River, US 64, Cherokee County.

Peachtree Creek, SR 1537

Peachtree Creek is a small (five meters wide) stream which originates on Big Peachtree Bald in the Valley River Mountains and flows into the Hiwassee River above Murphy. This rocky stream had a high EPT taxa richness (38) and a low EPT biotic index (2.91) and supported a pollution intolerant population of benthic invertebrates. This

stream continued to receive an Excellent bioclassification.

Valley River, SR 1554

The Valley River is the largest tributary of the Hiwassee River. The river near Tomotla is 20 m wide, with a drainage area of 104 mi². Total and EPT taxa richness at this Valley River site have remained relatively stable and there has been little change in the bioclassification (Table 9 and Figure 9). There was a slight increase in taxa richness in 1999 over 1994, probably due to the high flow conditions and the difficulty experienced in sampling in 1994.

Table 9. Flows and bioclassifications for the Valley River, SR 1554, Cherokee County.

Year	Flow	Rating
1984	High	Good-Fair
1986	Low	Good-Fair
1988	Low-Normal	Good-Fair
1990	Low-Normal	Good
1994	High	Good-Fair
1999	Normal	Good-Fair

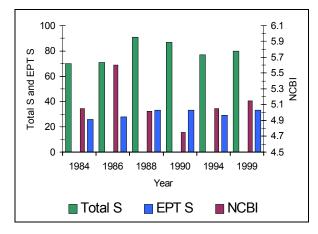


Figure 9. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for the Valley River, SR 1554, Cherokee County.

Junaluska Creek, SR 1505

Junaluska Creek is a small (6 mi² watershed) tributary of the Valley River. There was an increase in EPT taxa collected at this site resulting in a change in bioclass from Good-Fair in 1994 to Good in 1999 (Table 10 and Figure 10). Flows in 1994 were very high which made sampling difficult.

Table 10. Flows and bioclassifications for Junaluska Creek, SR 1505, Cherokee County.

Year	Flow	Rating
July 1994	High	Good-Fair
August 1994	High	Good-Fair
August 1999	Low	Good

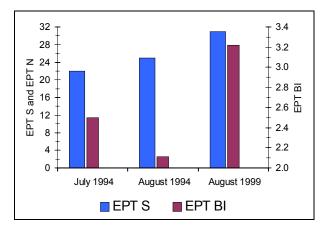


Figure 10. EPT (EPT S) taxa richness and biotic index (EPT Bl) for Junaluska Creek, SR 1505, Cherokee County.

Hanging Dog Creek, SR 1331

Hanging Dog Creek is a large tributary to Hiwassee Lake. This is a high gradient, rocky stream with a substrate dominated by boulders and rubble with little fine sediments indicating little erosion occurring in the watershed. Data collected at SR 1331 revealed a high EPT taxa richness (40) and low EPT Biotic Index (2.62) resulting in a bioclassification of Excellent as was found in 1994.

Nottely River, SR1596

The Nottely River, another major tributary (20 m wide) to the Hiwassee River, is impounded upstream in Georgia to form the Nottely Reservoir. There were indications of variable water levels at this site. The substrate was predominantly gravel and rubble, with little fine sediments.

The rating at this site decreased from Excellent in 1994 to Good in 1999. This was not a significant decline because there was a difference of only 3 EPT taxa between the two sampling periods. The Excellent rating in 1994 was also borderline.

There was a slight decrease in the number of EPT taxa collected and an increase in the EPT biotic index in 1999, suggesting a slightly more tolerant community. The snail *Physella* and amphipods were abundant at this site indicating low dissolved oxygen conditions. This was a result of the

releases from the upstream dam. The water temperature at this site (13 °C) was much lower than at other sites sampled that day (19 - 22 °C). This was another indication of the upstream discharge of hypolimnetic from Hiwassee Lake.

Persimmon Creek, SR 1127 and Beaverdam Creek, SR 1326

Persimmon Creek (seven meters wide) and Beaverdam Creek (14 m wide) are tributaries to Hiwassee Lake. Beaverdam Creek was characterized by boulders and sudden drop-offs. There were also silt deposits along the edge of the stream. Both streams supported a diverse and intolerant EPT community and continued to receive a bioclassification of Excellent.

South Shoal Creek, SR 1323

South Shoal Creek is an embedded, high gradient, rocky stream, with areas of severe bank erosion. It also is a tributary to Apalachia Lake. The stream was rated as Good in 1994 and 1999.

Shuler Creek, SR 1323

The bioclassification at this site increased from Good in 1994 to Excellent in 1999. This resulted from an increase in the number of EPT species collected (35 in 1994 and 40 in 1999). The lower taxa richness in 1994 was most likely a result of sampling under very high flow conditions.

SPECIAL STUDIES

Sites on the 303 (d) List

Three sites in this subbasin were on the 303(d) list of impaired waters of the state. Based on the ratings from the macroinvertebrate data collected in August 1999 (Table 11), the sites should be removed from the list.

Table 11. Benthos ratings of sites in Subbasin 02 in Cherokee County which are on the 303 (d) list, August 1999.

Waterbody	Location	S	EPT S	Rating ¹
Valley R	Bus. US 19		24	G-F
Valley R	Off SR 1315	63	28	G-F
Webb Cr	SR 1428	58	37	G

G = Good and G-F = Good-Fair.

Tennessee Valley Authority

During March 1999, TVA biologists collected information on fish, benthic invertebrates, and habitat characteristics at nine sites in this subbasin (unpublished data) (Table 12). The macroinvertebrate data were limited to the number of EPT families with a maximum score of about 25 families/site. The habitat assessment score had a maximum value of 52.

Table 12. Biological and habitat data collected by the Tennessee Valley Authority from Subbasin 02 in the Hiwassee River basin, March – August, 1999. Note: EPT ratings are not equivalent to Division ratings.

Waterbody	Location	County	No. of EPT Families	EPT Rating	No. of Fish Species	No. of Fish	TVA IBI	Habitat Score
Valley R	Off SR 1515 and US 19/74/129	Cherokee	15	Good	24	1282	52	34
Valley R	Near 1370 and US 19/129	Cherokee	15	Good	31	1019	58	28
South Shoal Cr	Near mouth	Cherokee	21	Excellent	3	116	28	42
Rapier Mill Cr	Off 1124	Cherokee	20	Excellent	10	449	40	41
Nottely R	Off 1124	Cherokee	18	Good	11		34	
L Brasstown Cr	Off SR 1565	Cherokee	16	Good	17	239	50	21
Hanging Dog Cr	Off SR 1349	Cherokee	16	Good	13	194	42	48
Brasstown Cr	SR 1564	Cherokee	21	Excellent	18	713	52	37
Beaverdam Cr	SR 1326	Cherokee	21	Excellent	13	631	42	42

Lake Assessment

Hiwassee Lake

Hiwassee Lake is an impoundment of the Hiwassee River near the North Carolina-Tennessee state border (Figure 11). Chatuge Lake is located upstream of Hiwassee Lake and Apalachia Lake is immediately downstream.

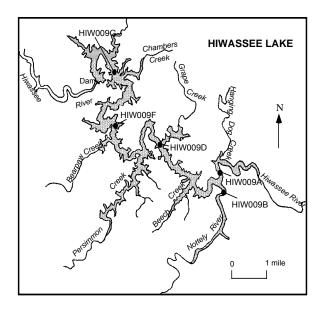


Figure 11. Monitoring sites at Hiwassee Lake, Cherokee County.

Hiwassee Lake, which is owned by the TVA, provides hydroelectric power, flood control, and recreational opportunities. The major tributaries are the Hiwassee River, Nottely River, Persimmon Creek, Valley River, Hanging Dog Creek, and Bearpaw Creek.

The lake was most recently sampled in July 1999 (Table 13 and Appendices L2 and L3). Secchi depths ranged from 2.7 to 3.5 m. Total phosphorus concentrations were less than the detection level (< 0.01 mg/l) at all sites. The greatest chlorophyll a concentration (31 μ g/l) was observed at the Nottely River arm site (HIW009B). The greatest lakewide mean chlorophyll a concentration was measured in July 1999 as compared with mean values observed in previous years (Appendix L3). Based on calculated NCTSI scores, Hiwassee Lake was oligotrophic.

Historical data from 1981 through 1999 for the four constituents of the NCTSI were summarized using box and whisker plots (Figure 12). Median total phosphorus was greatest at the two sampling sites located in the upper end of the lake (Stations HIW009A and HIW009B). Median total organic nitrogen was greatest at Station HIW009A. Mean Secchi depths were consistent among the sites; mean chlorophyll *a* concentrations were lowest at Station HIW009G.

There have been no reported fish kills, algal blooms, or problems with aquatic plants in Hiwassee Lake. There have been anecdotal reports of a declining fishery in the lake in recent years. Also in 1998, there was a brief sewage bypass from the Town of Murphy's wastewater treatment plant into the lake (Donald Anderson, Tennessee Valley Authority, pers. com).

In 1990, the TVA began a program to monitor the biological conditions of its reservoirs. The purpose of this program is to provide information on the integrity or "health" of the aquatic ecosystems of the reservoirs. The TVA rating system, which is not comparable to the rating method used by the Division, is based on the assignment of a numerical score which is then used to define each of five reservoir indicators as Poor, Fair, or Good.

The ecological health of Hiwassee Lake was rated as Fair in 1998 according to the program (Dycus, et al. 1999). This rating was similar to ratings for 1993, 1994, and 1996. The chlorophyll indicator was rated as Good at the forebay site. However, relatively high chlorophyll concentrations were measured at the mid-reservoir site (particularly in June when the lake was monitored a few days after a heavy rainfall event) resulted in a Poor rating. Benthic invertebrates also rated Poor at the mid-reservoir site. There were few benthic organisms at this site and those present were generally tolerant of poor water quality.

Table 13. Biological and water chemistry data from Hiwassee Lake and Apalachia Lake, 1994 - 1999.

Lake	Date	NCTSI	Rating	TP (mg/l)	TON (mg/l)	CHL a (µg/l)	Secchi (m)
Hiwassee Lake	07/28/1999	-4.0	Oligotrophic	< 0.01	0.11	21	3.1
	08/30/1994	-3.5	Oligotrophic	0.02	0.16	2	1.8
Apalachia Lake	07/28/1999	-4.9	Oligotrophic	< 0.01	0.10	10	3.2
	08/30/1994	-4.5	Oligotrophic	0.02	0.14	8	2.1

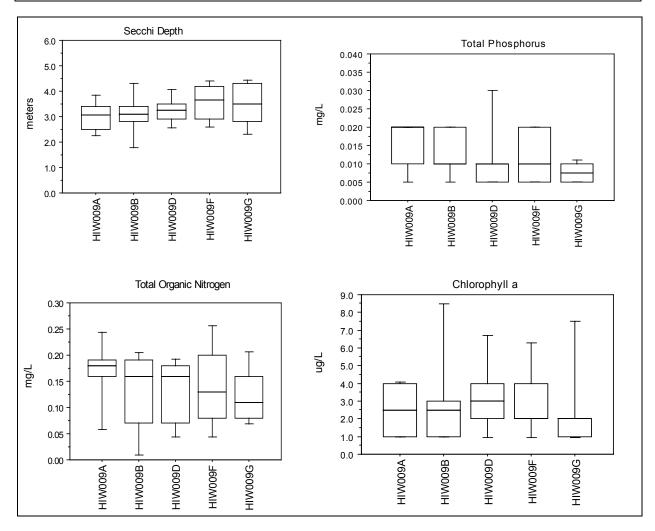


Figure 12. Spatial relationships among limnological data from Hiwassee Lake, 1981 – 1999 (n = 5).

Apalachia Lake

Apalachia Lake is a run-of-river reservoir located immediately downstream from Hiwassee Lake (Figure 13). The reservoir, owned by the TVA, provides hydroelectric power generation, flood control, and recreational opportunities. Major tributaries to the lake include the Hiwassee River, Camp Creek, and North and South Shoal Creeks.

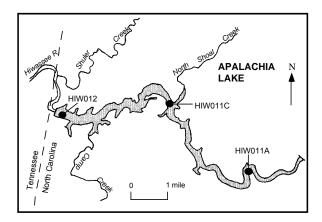


Figure 13. Monitoring sites at Apalachia Lake, Cherokee County.

The lake was most recently sampled in July 1999 (Table 13 and Appendices L2 and L3). Total phosphorus concentrations were less than the detection level (0.01 mg/l) at all sites. Chlorophyll a concentrations ranged from 4 µg/l at the upstream site to 14 µg/l at the mid-lake site. The 1999 mean chlorophyll a concentration lent credence to a slight increasing lakewide trend observed from 1981 to 1999 (Appendix L3).

Data collected from 1981 through 1999 for the four constituents of the NCTSI were summarized using box and whisker plots (Figure 14). Median Secchi

depths were consistent among the sites. Median total organic nitrogen concentrations demonstrated a typical reservoir spatial decrease (i.e., from upstream to downstream). Chlorophyll *a* concentrations demonstrated the opposite pattern. The greatest median was observed at the site located nearest the dam. The lowest median total phosphorus concentration was observed at the mid-lake sampling site (Station HIW0111C).

There have been no reports of fish kills, algal blooms, problems with aquatic macrophytes, or complaints from swimmers regarding water quality issues in Apalachia Lake. There have also been no reports regarding odors or decreases in water clarity. The watershed of Apalachia Lake is located in the Nantahala National Forest and is stable regarding developmental pressures (Donald Anderson, TVA, pers. com).

As stated previously for Chatuge Lake and Hiwassee Lake, in 1990, the TVA began a program to monitor the biological conditions of its reservoirs. The purpose of this program is to provide information on the integrity or "health" of the aquatic ecosystems of the reservoirs. The TVA rating system, which is not comparable to the rating method used by the Division, is based on the assignment of a numerical score which is then used to define each of five reservoir indicators as Poor, Fair, or Good.

In 1998, the ecological health of Apalachia Lake was rated as Fair according to the program (Dycus, et al. 1999). Of the five indicators examined, only chlorophyll rated Good in 1998. The other four indicators (sediment quality, fish assemblage, dissolved oxygen, and benthic invertebrates) were rated as Fair.

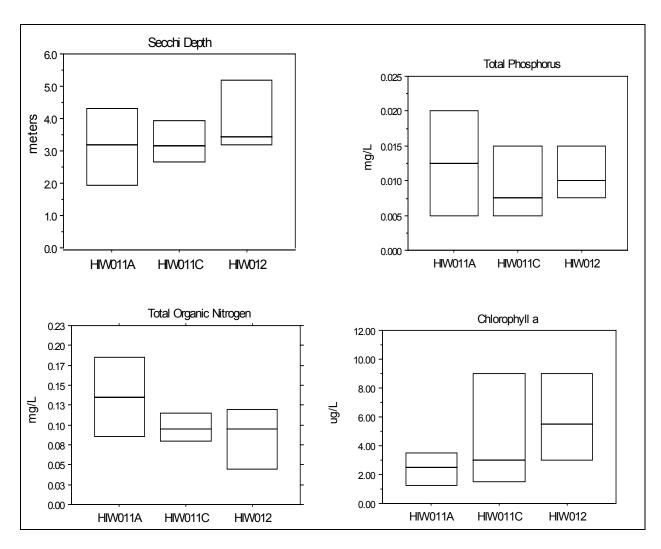


Figure 14. Spatial relationships among limnological data from Apalachia Lake, 1981 – 1999 (n = 4).

AMBIENT MONITORING SYSTEM

The Division collects ambient water quality information from approximately 421 active monitoring stations statewide. In the Hiwassee River basin there are two stations (Tables 14 - 17 and Figure 15).

Regional flow patterns generally showed greater than normal flows beginning in 1994 to about 1998 (Figure 16). Beginning in 1998, yearly and monthly median flows displayed decreases. The graph depicting flow in the Hiwassee River does not

include data for the water year 1998 - 1999, but the yearly median flow followed the patterns for the yearly median for the Watauga and Little Tennessee rivers

The previous basinwide assessment report (NCDEHNR 1996a) noted few concerns with water quality in this basin. However, the report noted a period of low pH between 1991 and 1994, and that four fecal coliform samples exceeded a concentration of 200 colonies/100 ml.

Table 14. Ambient monitoring system stations within the Hiwassee River basin.

Drainage	Subbasin	Station Code	Station	County	Class
Hiwassee	040502	F2500000	Hiwassee River above Murphy	Cherokee	WS-V
	040502	F4000000	Valley River at SR 1373 at Tomotla	Cherokee	C Tr

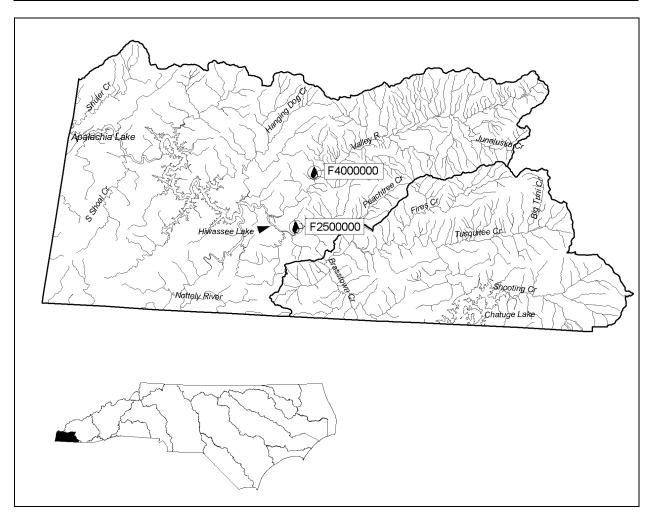


Figure 15. Ambient monitoring system stations within the Hiwassee River basin.

The period of low pH during the early 1990's (Figure 17) had been observed in other mountain basins. In all cases, these low pH observations occurred during 1991 and 1994. After 1994, pH values increased. There were no known reasons for the low pH observed during the early 1990s. Atmospheric deposition has been speculated but there was also the possibilities of monitoring personnel error and pH meter equipment variability.

During the period from October 1994 to August 1998, there were 11 pH values of 8.0 or greater (Figure 17). Only one observation of 8.0 or greater (8.0 on 06/30/1992 at the Valley River) was observed previous to October 1994. There is no known reason why pH has increased slightly since 1995.

Fecal coliform bacteria information is provided in Table 15. This table compares the geometric mean and proportion of samples greater than 200 colonies/100 ml for three time periods. Overall there has been a decrease in the geometric mean and proportion of samples that exceed a reference value of 200 colonies/100 ml.

The recent basinwide monitoring data from 1994-1999 showed few samples exceeding reference levels. The values of turbidity that are labeled (Figure 18) corresponded to high flows in the Hiwassee River, thus suggesting recent runoff. The fecal coliform bacteria concentrations that exceeded the reference value of 200 colonies/100 ml corresponded to the labeled turbidity values. Total coliform concentrations collected from the Hiwassee River, classified as a water supply, often exceeded the reference value of 50 colonies/100 ml (Table 15).

No temporal patterns could be noted except for the recent decreases in fecal coliform bacteria (Table 15 and Figure 18). One elevated nitrite+nitrate nitrogen concentration (5.9 mg/l) was observed during March 29, 1995.

Most observations for metals were less than the Division reporting levels. Iron, manganese, and aluminum were the exceptions because these elements are commonly found in soils. Although 6% of the observations for copper exceeded the reference concentration of 7 μ g/l, 90% of the observations were less than 6.5 μ g/l.

Table 15. Summary of fecal coliform bacteria collections from the Hiwassee River basin, 1973 - 1999¹.

Site	First Sample	Last Sample	N^2	Geometric Mean	N > 200	% > 200
Hiwassee R	06/27/1973	06/15/1989	77	160.4	29	37.7
	09/06/1989	08/29/1994	15	5.9	1	6.7
	09/28/1994	08/26/1999	49	3.4	3	6.1
Valley R	11/19/1973	08/24/1989	133	367.0	93	69.9
•	09/06/1989	08/29/1994	18	24.0	3	16.7
	09/28/1994	08/26/1999	49	19.2	6	12.2

Row in bold face represents the summary for the current basin assessment period (09/01/1994 to 08/31/1999).

² N = Number of samples; N > 200 = number of samples > 200 colonies/100ml; % > 200 = proportion (%) of samples > 200 colonies/100 ml.

Table 16. Summary of water quality parameters collected from the Hiwassee River (Station F2500000; Class WS-V) during the period September 1, 1994 to August 31, 1999.

							_		Pei	centile	es	
Davamatas		No. < RL	Def	N. Def	% >	N/I:	Max	40	25	50	75	00
Parameter	N	KL	Ref.	N>Ref.	Ref .	Min.	Max	10	25	50	75	90
Field												
Temperature (°C)	55					6	23	7	9	15	19	21
Conductivity	54					17	42	22	25	26	29	32
Dissolved Öxygen	55		5	0		8.3	14.5	8.8	9.3	10.2	11.1	11.8
pH (s.u.)	54		6-9	0		6.1	9.0	6.8	7.0	7.2	7.5	7.9
Other												
Total Residue	49	0	500	0		16	180	24	32	46	55	74
Total Sus. Solids	48	5				1	140	1	3	6	9	18
Hardness	49	0	100	0		3	18	4	5	7	9	10
Chloride	47	2	250			1	4	1	1	2	2	2
Turbidity (NTU)	48	0	50	2	4.2	1.8	150.0	2.5	3.2	4.6	7.6	15.4
Bacteria												
Total coliform	49	1	50	30	61.2	4	8400	22	34	100	218	546
Fecal coliform	49	10	200	3	6.1	1	1400	1	1	1	6	43
Nutrients												
NH ₃ as N	50	13				0.01	0.11	0.01	0.01	0.03	0.05	0.08
TKN as N	50	4				0.1	0.5	0.1	0.1	0.1	0.2	0.3
NO ₂ +NO ₃ as N	50	0	10	0		0.02	5.90	0.09	0.12	0.15	0.19	0.25
Total Phosphorus	50	17	-			0.01	0.21	0.01	0.01	0.01	0.02	0.03
Metals (total)												
Arsenic	50	50	50	0		10	10	10	10	10	10	10
Cadmium	50	50	2	N/A		2	2	2	2	2	2	2
Chromium	50	50	50	0		25	25	25	25	25	25	25
Copper	50	25	7	3	6.0	2	22	2.0	2.0	2.0	4.0	6.5
Iron	49	0	1000	0		130	6500	168	210	290	415	932
Lead	50	47	25	0		10	17	10	10	10	10	10
Manganese	4	0	200	0		14	68	. :	21	29	49	
Nickel	50	50	25	0		10	10	10	10	10	10	10
Aluminum	49	2				50	5800	62	115	160	323	680
Mercury Abbreviations:	50	50	0.012	N/A		0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N Total number of samples.

N < RL Number of samples less than the Division analytical reporting level (RL).

Ref Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.

N > Ref Number of samples greater than (or less than) the reference.

% > Ref Proportion (%) of samples greater than the reference.

Min Minimum. Max Maximum.

N/A Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = μ mhos/cm; bacteria = no. colonies/100 ml; metals = μ g/l; all others = mg/l.

Table 17. Summary of water quality parameters collected from the Valley River (Station F4000000; Class C Tr) during the period September 1, 1994 to August 31, 1999.

							_		Pei	rcentile	s	
Parameter	N	No. < RL	Ref.	N > Ref.	% > Ref.	Min.	Max.	10	25	50	75	90
Field												
Temperature (°C)	55	_				5	26	6	10	14	21	23
Conductivity ` ´	54					27	77	33	36	43	55	63
Dissolved Oxygen	55		6	0		7.7	14.7	8.2	9.0	10.2	11.1	12.4
pH (s.u.)	55		6-9	0		6.3	8.9	7.0	7.2	7.4	7.7	8.0
Other												
Total Residue	1	0				1	1			1		
Total Sus. Solids	48	5		•		1	51	1	2	4	8	13
Hardness	49	0			•	4	38	8	12	15	19	24
Chloride	0	0	230		8.2	1.2	24.0		. 4 7			0.7
Turbidity (NTU)	49	0	10	4	8.2	1.2	34.0	1.4	1.7	2.4	3.6	9.7
Bacteria												
Total coliform	0											
Fecal coliform	49	6	200	6	12.2	1	1100	1	4	23	59	238
Nutrients												
NH₃ as N	53	19				0.01	0.11	0.01	0.01	0.03	0.05	0.07
TKN as N	53	4				0.1	0.4	0.1	0.1	0.1	0.2	0.3
NO ₂ +NO ₃ as N	53	1				0.01	0.48	0.12	0.15	0.19	0.20	0.33
Total Phosphorus	53	11	•	•		0.01	0.15	0.01	0.01	0.02	0.02	0.04
Metals (total)												
Arsenic	52	52	50	0		10	10	10	10	10	10	10
Cadmium	52	52	0.04	N/A ²		2	2	2	2	2	2	2
Chromium	52	52	50	0	:	25	25	25	25	25	25	25
Copper	52	24	7	4	7.7	2	13	2.0	2.0	2.1	4.3	7.0
Iron	51	0	1000	5	9.8	98	2500	110	163	220	380	866
Lead	52	49	25	0	•	10	25	10	10	10	10	10
Manganese Nickel	2 52	0 52	88		•	12 10	19 10	10	12 10	16 10	19 10	10
Aluminum	52 51	52 4	00	U	•	50	2000	64	83	130	248	770
Mercury	52	52	0.012	N/A ²	•	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Abbreviations:	- 02		0.012	14//1	<u> </u>	U.Z	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

Total number of samples.

N < RL

Number of samples less than the Division analytical reporting level (RL).
Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200. Ref

N > Ref Number of samples greater than (or less than) the reference.

Proportion (%) of samples greater than the reference. % > Ref

Min Minimum. Maximum. Max

Not applicable because all samples were less than the reporting level. N/A

Units of Measurement

As noted. Conductivity = μ mhos/cm; bacteria = no. colonies/100 ml; metals = μ g/l; all others = mg/l.

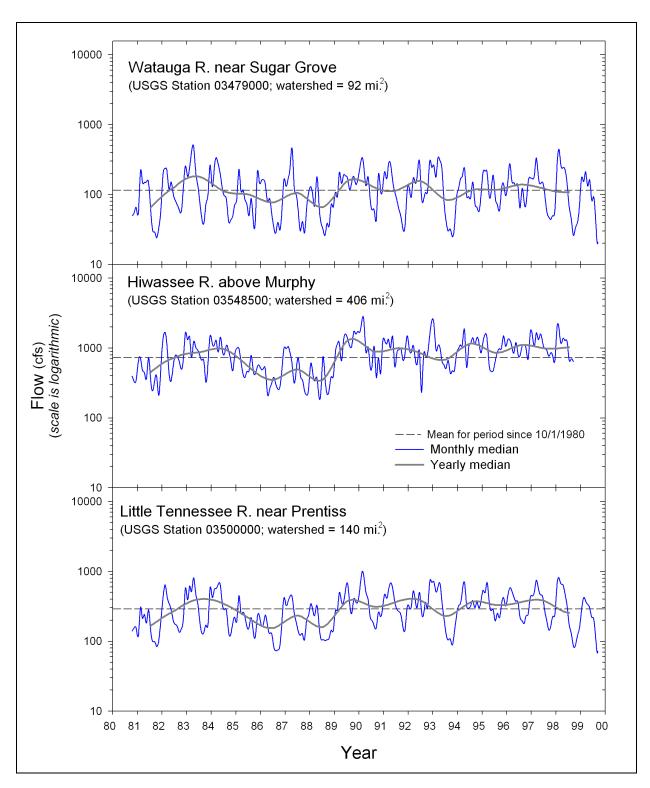


Figure 16. Regional patterns for river flow, 1980 - 1999. (Data from US Geological Survey: http://nc.water.usgs.gov/).

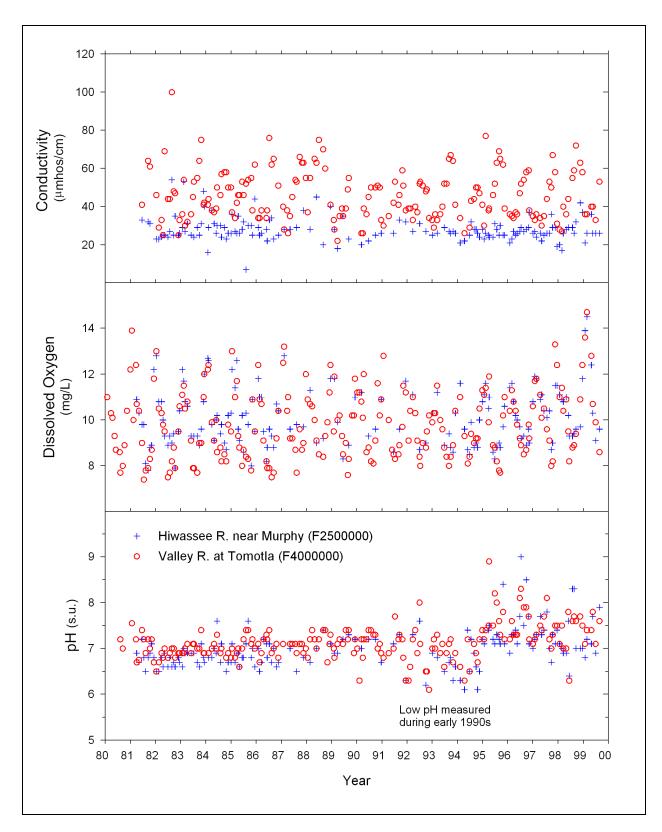


Figure 17. Temporal patterns for conductivity, dissolved oxygen, and pH in the Hiwassee River basin during the period 1980 - 1999.

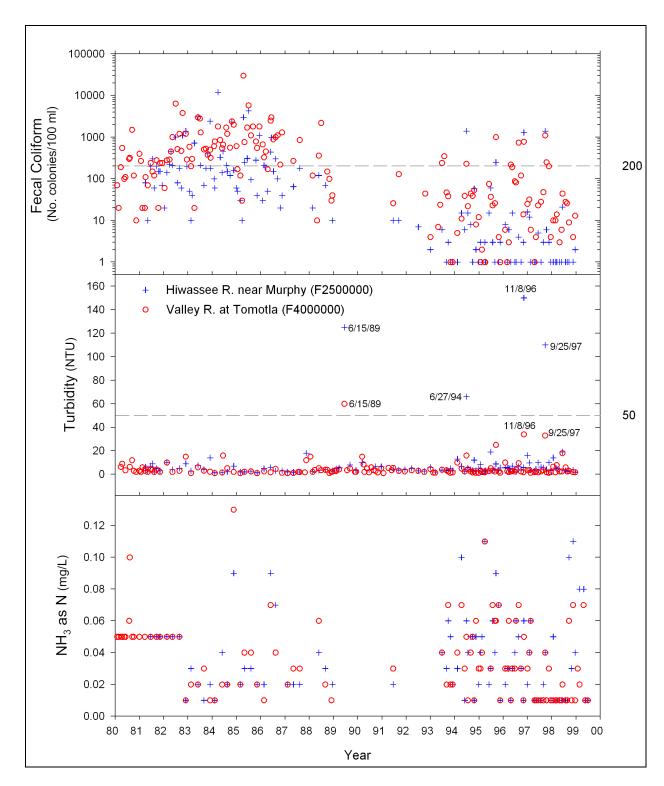


Figure 18. Temporal patterns for fecal coliform bacteria, turbidity, and ammonia – nitrogen (NH₃) in the Hiwassee River basin during the period 1980 - 1999. Dashed lines represent Reference Values.

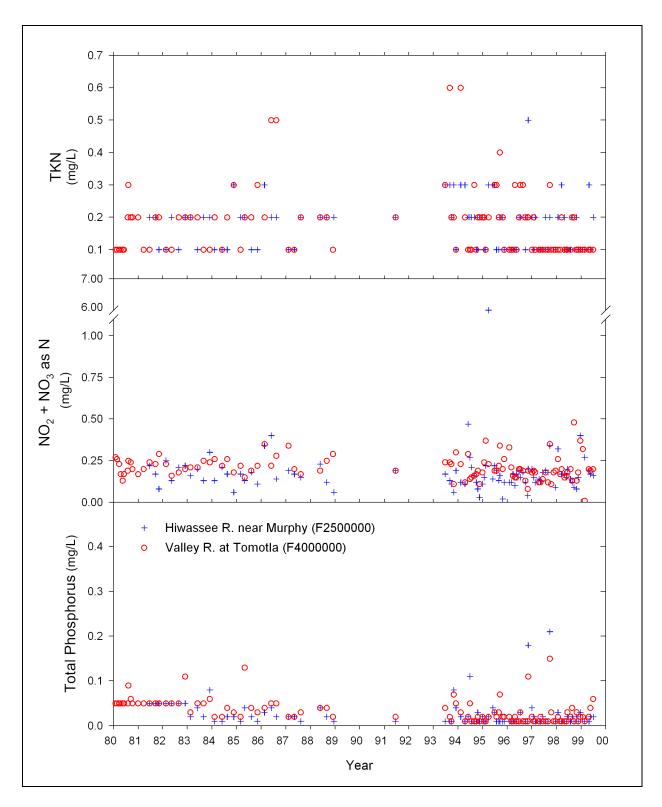


Figure 19. Temporal patterns for total Kjeldahl nitrogen (TKN), nitrite+nitrate nitrogen (NO₂+NO₃), and total phosphorus in the Hiwassee River basin during the period 1980 - 1999.

AQUATIC TOXICITY MONITORING SUMMARY

Three facilities in the Hiwassee River basin have NPDES permits which require whole effluent toxicity (WET) monitoring. These facilities are the Clay County and the towns of Andrews and Murphy wastewater treatment plants. (Figure 20 and Table 18). All three facilities also have a WET permit limit.

Whole effluent toxicity limits were not written into permits in North Carolina until 1987. Since 1988, these three facilities in the basin have been required to monitor their effluent for whole effluent toxicity. Since 1990, the compliance rate has fluctuated between 90 and 95% (Figure 21).

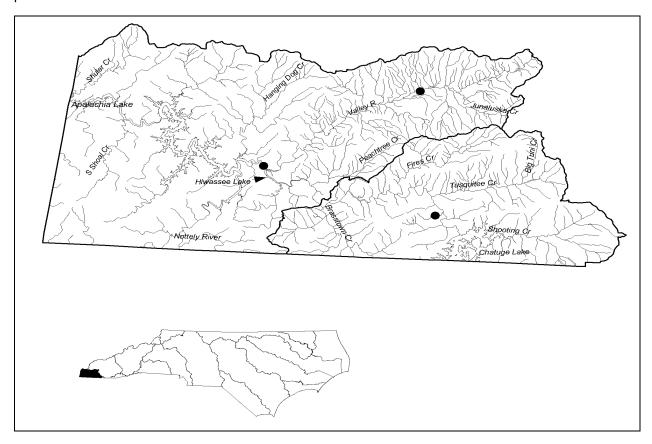


Figure 20. Locations of facilities in the Hiwassee River basin required to perform whole effluent toxicity testing.

Table 18. Facilities in the Hiwassee River basin required to perform whole effluent toxicity testing and their compliance records.

Facility	Clay County WWTP	Andrews WWTP	Murphy WWTP
NPDES Permit No.	NC0021547/001	NC0026557/001	NC0039578/001
Receiving stream	Hiwassee R	Valley R	Hiwassee R
County	Clay	Cherokee	Cherokee
Permitted flow (MGD)	0.3	1.5	0.925
7Q10	0.5	15.0	96.9
IWC ¹ (%)	23	13	1.5
Pre-1999 passes ²	44	45	42
Pre-1999 fails	9	8	2
1999 passes ²	3	5	3
1999 fails	0	1	0

Instream waste concentration

² Note that "pass" denotes meeting a permit limit. The actual test result may be a "pass" (from a pass/fail acute or chronic test), LC₅₀, or chronic value. Conversely, "fail" means failing to meet a permit limit or target value.

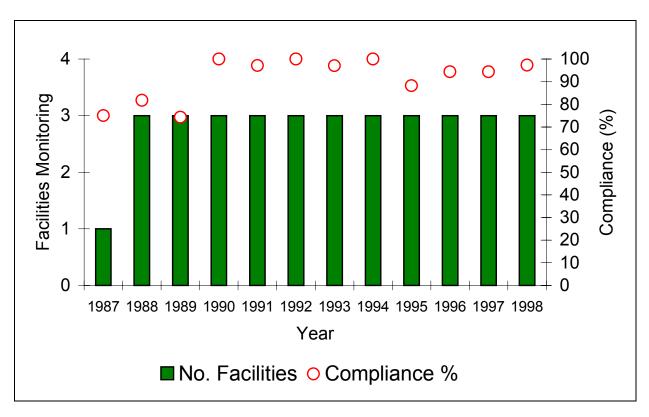


Figure 21. Compliance record of facilities in the Hiwassee River basin required to perform whole effluent toxicity testing, 1987 - 1998. The compliance values were calculated by determining whether a facility was meeting its ultimate permit limit during the given time period, regardless of any SOCs in force.

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GLOSSARY

7Q10 A value which represents the lowest average flow for a seven day period that will

recur on a ten year frequency. This value is applicable at any point on a stream. 7Q10 flow (in cfs) is used to allocate the discharge of toxic substances to

streams.

Bioclass Criteria have been developed to assign bioclassifications ranging from Poor to

Excellent to each benthic sample based on the number of taxa present in the

intolerant groups (EPT) and the Biotic Index value.

cfs Cubic feet per second, generally the unit in which stream flow is measured.

CHL a Chlorophyll a.

Division The North Carolina Division of Water Quality.

D.O. Dissolved Oxygen.

Ecoregion An area of relatively homogeneous environmental conditions, usually defined by

elevation, geology, and soil type. Examples include mountains, piedmont, coastal

plain, sandhills, and slate belt.

EPT The insect orders (Ephemeroptera, Plecoptera, Trichoptera); as a whole, the

most intolerant insects present in the benthic community.

EPT N The abundance of Ephemeroptera, Plecoptera, Trichoptera insects present,

using values of 1 for Rare, 3 for Common and 10 for Abundant.

EPT S Taxa richness of the insect orders Ephemeroptera, Plecoptera and Trichoptera.

Higher taxa richness values are associated with better water quality.

HQW High Quality Waters.

IWC Instream Waste Concentration. The percentage of a stream comprised of an

effluent calculated using permitted flow of the effluent and 7Q10 of the receiving

stream.

Major Discharger Greater than or equal to one million gallons per day discharge (≥ 1 MGD).

MGD Million Gallons per Day, generally the unit in which effluent discharge flow is

measured.

Minor Discharger Less than one million gallons per day discharge (< 1 MGD).

NPDES National Pollutant Discharge Elimination System.

NCBI (EPT BI)

North Carolina Biotic Index, EPT Biotic Index. A summary measure of the

tolerance values of organisms found in the sample, relative to their abundance.

Sometimes noted as the NCBI or EPT BI.

NCIBI North Carolina Index of Biotic Integrity (NCIBI); a summary measure of the effects

of factors influencing the fish community.

NSW Nutrient Sensitive Waters.

NTU Nephelometric Turbidity Unit.

GLOSSARY (continued)

ORW Outstanding Resource Waters.

Parametric Coverage A listing of parameters measured and reported.

SOC A consent order between an NPDES permittee and the Environmental

Management Commission that specifically modifies compliance responsibility of

the permittee, requiring that specified actions are taken to resolve non-

compliance with permit limits.

Total S (or S) The number of different taxa present in a benthic macroinvertebrate sample.

UT Unnamed tributary.

WWTP Wastewater treatment plant.

Web Sites Basinwide planning -- http://h2o.enr.state.nc.us/basinwide/basinwide/default.html

Biological monitoring -- http://www.esb.enr.state.nc.us/bau.html

Fish kills -- http://www.esb.enr.state.nc.us/fishkill/fishkill00.html

North Carolina Administrative Code that relates to the Division of Water Quality and water quality protection -- http://h2o.enr.state.nc.us/rules/ruleindex.html

Appendix B1. Benthic macroinvertebrate sampling and criteria for freshwater wadeable and flowing waters.

Benthic macroinvertebrates can be collected using two sampling procedures. The Division's standard qualitative sampling procedure includes 10 composite samples: two kick-net samples, three bank sweeps, two rock or log washes, one sand sample, one leafpack sample, and visual collections from large rocks and logs (NCDEHNR 1997b).

An abbreviated method (4-sample EPT) includes one kick-net sample, one bank sweep, one leaf pack sample, and visual collections from large rocks and logs. Only EPT groups are collected and identified, and only EPT criteria are used to assign a bioclassification. "EPT" is an abbreviation for Ephemeroptera + Plecoptera + Trichoptera, insect groups that are generally intolerant of many kinds of pollution. Higher EPT taxa richness values usually indicate better water quality.

The purpose of these collections is to inventory the aquatic fauna and produce an indication of relative abundance for each taxon. Organisms are classified as Rare (1-2 specimens), Common (3-9 specimens), or Abundant (≥ 10 specimens).

Several data-analysis summaries (metrics) can be produced to detect water quality problems (Table B1.

Table B1. Benthos classification criteria for flowing water systems in the mountain ecoregion.

Metric	Sample	Bioclass	Score
	type		
EPT S	10-sample	Excellent	> 41
	Qualitative	Good	32 - 41
		Good-Fair	22 - 31
		Fair	12 - 21
		Poor	0 - 11
	4-sample EPT	Excellent	> 35
	•	Good	28 - 35
		Good-Fair	19 - 27
		Fair	11 - 18
		Poor	0 - 10
Biotic Index	10-sample	Excellent	< 4.05
(range 0 – 10)	Qualitative	Good	4.06 - 4.88
		Good-Fair	4.89 - 5.74
		Fair	5.75 - 7.00
		Poor	> 7.00

These metrics are based on the idea that unstressed streams and rivers have many invertebrate taxa and are dominated by intolerant species. Conversely, polluted streams have fewer numbers of invertebrate taxa and are dominated by tolerant species. The diversity of the inverte-brate fauna is evaluated using taxa richness counts; the tolerance of the stream community is evaluated using a biotic index.

EPT taxa richness (EPT S) is used with criteria to assign water quality ratings (bioclassifications). Water quality ratings also are based on the relative tolerance of the macroinvertebrate community as summarized by the North Carolina Biotic Index (NCBI). Tolerance values for individual species and the final biotic index values have a range of 0-10, with higher numbers indicating more tolerant species or more polluted conditions.

Water quality ratings assigned with the biotic index numbers are combined with EPT taxa richness ratings to produce a final bioclassification, using criteria for Mountain streams. EPT abundance (EPT N) and total taxa richness calculations also are used to help examine between-site differences in water quality. If the EPT taxa richness rating and the biotic index differ by one bioclassification, the EPT abundance value is used to determine the final site rating.

The expected EPT taxa richness values are lower in small high-quality mountain streams (< 4 m wide or with a drainage area < 3.5 mi²). For these small mountain streams, an adjustment to the EPT taxa richness values is made prior to applying taxa richness criteria.

EPT taxa richness and biotic index values also can be affected by seasonal changes. Criteria for assigning bioclassification are based on summer sampling: June-September. For samples collected outside summer, EPT taxa richness can be adjusted by subtracting out winter/spring Plecoptera or other adjustment based on resampling of summer site. The biotic index values also are seasonally adjusted for samples outside the summer season.

Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis.

Appendix B2. Benthic macroinvertebrate data collected in the Hiwassee River basin, 1983 - 1999. Current basinwide monitoring sites have the Map No. bolded.

Subbasin/ Stream	Location	County	Map 1 No.	Index No.	Date	S/ EPT S	NCBI EPT BI	Bio Class ¹
O1	CD 4240	Clave	D 4	4.5	00/04	00/07	0.07/0.00	
Shooting Cr (above chicken farm) Shooting Cr (below confluence of UT)	SR 1349 SR 1168	Clay Clay	B-1 B-2	1-5 1-5	08/94 08/94	68/37 59/28	2.97/2.22 3.24/2.73	G G
Shooting Cr (below confidence of 01) Shooting Cr	SR 1100 SR 1340	Clay	B-3	1-5 1-5	08/94	-/30	-/2.57	G
Chooling Or	010 1040	Olay	D-3	1-0	07/94	-/32	-/2.36	G
Tusquitee Cr (above trout farm)	Off SR 1307	Clay	B-4	1-21-(0.5)	03/89	-/35	-/2.14	Ğ
Tusquitee Cr (above Big Tuni Cr)	SR 1307	Clay	B-5	1-21-(0.5)	03/89	-/49	-/2.49	Ě
Tusquitee Cr	SR 1330	Clay	B-6	1-21-(4.5)	07/94	69/33	3.79/2.82	G
					03/89	-/45	-/2.25	Е
					04/87	95/53	3.24/2.47	Ē
Die Tuni Ce (haaduustass)	HCEC D4 440	Class	D 7	4 04 5	05/87	101/51	3.23/2.33	E =2
Big Tuni Cr (headwaters)	USFS Rd 440	Clay	B-7	1-21-5	03/89 06/88	-/46 -/41	-/1.46 -/1.24	
					04/88	-/41 -/39	-/1.2 4 -/1.37	E
					05/87	90/46	2.19/1.34	G E E E E E E E
					04/87	77/38	2.06/1.44	Ē
Big Tuni Cr	SR 1311	Clay	B-8	1-21-5	08/99	-/45	-/1.63	Ε
-		•			07/94	63/37	2.11/1.57	Е
					03/89	83/45	2.89/2.10	Е
Johnson Mill Cr	SR 1307	Clay	B-9	1-21-13	03/89	-/42	-/1.71	E
Tusquitee Cr	SR 1300	Clay	B-10	1-21-(16.5)	08/99	82/39	3.56/2.81	E
Cranery Cr	CD 4040	Class	D 44	4 04 00 (0)	03/89	90/47	3.12/2.37 -/2.38	E 3
Greasy Cr Albone Cr	SR 1318 SR 1300	Clay	B-11 B-12	1-21-20-(2) 1-24	03/89 05/87	-/38 79/37	-/2.38 2.96/1.80	G3
Alborie Ci	SK 1300	Clay	D-12	1-24	04/87	79/37 77/38	3.15/2.10	⊏ =3
Fires Cr (headwaters)	USFS Rd C	Clay	B-13	1-27-(0.5)	06/88	-/35	-/1.15	E E E G E E E E E
r nos er (nodamatere)	00101140	Ciay	В 10	1 27 (0.0)	04/88	-/39	-/1.19	E^3
Coldspring Br	USFS Rd	Clay	B14	1-27-4-3	06/88	-/39	-/1.90	Ε
		•			04/88	-/37	-/1.33	Ε
Fires Cr (at Bristol Camp)	Off SR 1344	Clay	B-15	1-27-(5.5)	07/94	80/43	2.73/1.77	Ē
					06/88	102/47	3.06/1.75	E
					04/88	103/54	2.70/1.72	E E
Fires Cr (at picnic area)		Clay	B-16	1-27-(5.5)	05/87 08/99	95/52 77/44	2.95/1.97 2.98/2.48	Ē
riles or (at pichic area)		Clay	D-10	1-27-(3.3)	08/94	81/36	3.58/2.39	G
					07/94	-/35	-/1.78	Ğ
					08/88	107/54	3.54/2.61	Ě
					04/88	-/48	-/1.47	Е
					05/87	113/58	2.89/2.03	Ε
					04/87	101/54	2.68/1.97	E
Fires Cr	CD 4200	Class	D 47	4 07 (5 5)	08/85	111/50	4.03/2.37	E
Fires Cr	SR 1300	Clay	B-17	1-27-(5.5)	05/87 04/87	-/41 -/43	-/2.14 -/2.27	E E
L Fires Cr (near mouth)	USFS Rd	Clay	B-18	1-27-7	12/91	-/34	-/1.75	Ē
2 mos or (noar moath)	0010114	Olay	В 10		06/88	-/38	-/1.46	Ē
					04/88	-/37	-/1.43	Ē
Leatherwood Br	USFS Rd	Clay	B-19	1-27-12	06/88	-/30	-/2.25	E_2^2
					04/88	-/34	-/1.78	E ²
					05/87	60/30	2.81/1.80	E ²
Brasstown Cr	SR 1104	Clay	D 20	1-42	04/87 08/99	58/34 77/44	2.12/1.44 4.63/3.88	E ² E ² E ² G
Diassiowii Ci	SK 1104	Clay	B-20	1-42	07/94	-/18	-/4.41	F
02					01134	-/ 10	74.41	'
Hiwassee R (near Murphy)	US 64	Cherokee	B-1	1-(43.7)	08/99	73/36	4.42/3.53	G
				, ,	08/90	79/38	4.43/3.40	Ğ
					08/87	78/35	4.77/3.47	G
					07/86	65/32	4.97/3.98	G-F
					08/85	56/25	4.49/3.77	G
					08/84 08/83	67/29	4.60/3.56	G G-F
					00/03	62/23	4.77/3.62	G-F

Appendix B2 (continued).

Subbasin/			Мар	Index		S/	NCBI	Bio
Stream	Location	County	No. ¹	No.	Date	EPT S	EPT BI	Class ¹
Peachtree Cr	SR 1537	Cherokee	B-2	1-44	08/99	-/38	-/2.91	Е
					07/94	-/37	-/2.42	Ε
Valley R (near Rhodo)	Off US 19	Cherokee	B-3	1-52	08/94	-/23	-/2.84	G-F
Valley R (above Andrews)	SR 1389	Cherokee	B-4	1-52	08/94	-/15	-/3.30	F
Valley R (above WWTP)	Bus. US 19	Cherokee	B-5	1-52	08/99	-/24	-/4.75	G-F
					08/94	40/6	5.97/2.47	F
Valley R (above Andrews WWTP)		Cherokee		1-52	08/85	76/33	5.34/3.97	G-F
Valley R (below Andrews WWTP)		Cherokee		1-52	08/85	75/30	5.72/3.86	G-F
Valley R (above landfill)	Off US 19	Cherokee		1-52	08/94	57/13	5.51/4.00	F
Valley R (below landfill)	Off SR 1315	Cherokee		1-52	08/99	63/28	5.26/4.49	G-F
Valley R (near Tomotla)	SR 1554	Cherokee	B-10	1-52	08/99	80/33	5.15/4.27	G-F
					07/94	77/29	5.05/4.37	G-F
					08/90	87/33	4.75/3.88	G
					08/88	91/33	5.02/4.29	G-F
					07/86	71/28	5.60/4.04	G-F
					08/84	70/26	5.05/4.16	G-F
Junaluska Cr	SR 1505	Cherokee	B-11	1-52-25	08/99	-/31	-/3.22	G
					07/94	-/25	-/2.11	G-F
					08/94	-/22	-/2.50	G-F
Britton Cr (near SR 1339)	Off USFS Rd	Cherokee		1-52-29-(1)	12/91	-/35	-/1.54	Ε
Webb Cr	SR 1428,	Cherokee		1-52-32	08/99	58/37	3.21/2.80	G
Hanging Dog Cr	SR 1331	Cherokee	B-14	1-57	08/99	-/40	-/2.62	E E
					07/94	-/46	-/2.49	Е
Nottely R	SR 1596	Cherokee	B-15	1-58	08/99	-/33	-/3.54	G
					07/94	-/36	-/2.83	Е
Persimmon Cr	SR 1127	Cherokee	B-16	1-63	08/99	-/40	-/3.65	Е
					07/94	-/42	-/2.97	Е
Beaverdam Cr	SR 1326	Cherokee	B-17	1-72	08/99	-/38	-/2.76	
					08/94	-/39	-/2.45	Ε
South Shoal Cr	SR 1314	Cherokee	B-18	1-77	0/899	-/33	-/2.55	G
					08/94	-/30	-/2.40	G
Shuler Cr	SR 1323	Cherokee	B-19	1-86	08/99	-/40	-/2.78	Е
					08/94	-/35	-/2.42	G

 $^{^{1}}$ E = Excellent, G = Good, G-F = Good-Fair, and F = Fair. 2 Small stream criteria

Appendix L1. Lake Assessment Program

Numerical indices are often used to evaluate the trophic state of lakes. An index was developed specifically for North Carolina lakes as part of the state's original Clean Lakes Classification Survey (NCDNRCD 1982). The North Carolina Trophic State Index (NCTSI) is based on total phosphorus (TP in mg/l), total organic nitrogen (TON in mg/l), Secchi depth (SD in inches), and chlorophyll *a* (CHL in µg/L). Lakewide means for these parameters are used to produce a NCTSI score for each lake, using the equations:

$$\begin{aligned} \text{TON}_{\text{Score}} &= & ((\text{Log (TON)} + 0.45)/0.24)*0.90 \\ \text{TP}_{\text{Score}} &= & ((\text{Log (TP)} + 1.55)/0.35)*0.92 \\ \text{SD}_{\text{Score}} &= & ((\text{Log (SD)} - 1.73)/0.35)*-0.82 \\ \text{CHL}_{\text{Score}} &= & ((\text{Log (CHL)} - 1.00)/0.48)*0.83 \\ \text{NCTSI} &= & & \text{TON}_{\text{Score}} + \text{TP}_{\text{Score}} + \text{SD}_{\text{Score}} + \\ & & \text{CHL}_{\text{Score}} \end{aligned}$$

In general, NCTSI scores relate to trophic classifications (Table L1). When scores border between classes, best professional judgment is used to assign an appropriate classification. NCTSI scores may be skewed by highly colored water typical of dystrophic lakes. Some variation in the trophic state of a lake between years is not unusual because of the potential variability of data collections which usually involve sampling a limited number of times during the growing season.

Table L1. Lakes classification criteria.

NCTSI Score	Trophic classification
< -2.0	Oligotrophic
-2.0 - 0.0	Mesotrophic
0.0 - 5.0	Eutrophic
> 5.0	Hypereutrophic

Lakes are classified for their "best usage" and are subject to the state's water quality standards. Primary classifications are C (suited for aquatic life propagation /protection and secondary recreation such as wading), B (primary recreation, such as swimming, and all class C uses), and WS-I through WS-V(water supply source ranging from highest watershed protection level I to lowest watershed protection V, and all class C uses).

Lakes with a CA designation represent water supplies with watersheds that are considered Critical Areas (i.e., an area within 0.5 mile and draining to water supplies from the normal pool elevation of reservoirs, or within 0.5 mile and draining to a river intake).

Supplemental classifications may include SW (slow moving Swamp Waters where certain water quality standards may not be applicable), NSW (Nutrient Sensitive Waters subject to excessive algal or other plant growth where nutrient controls are required), HQW (High Quality Waters which are rated excellent based on biological and physical/chemical characteristics), and ORW (Outstanding Resource Waters which are unique and special waters of exceptional state or national recreational or ecological value). A complete listing of these water classifications and standards can be found in Title 15 North Carolina Administrative Code, Chapter 2B, Section .0100 and .0200.

Appendix L2. Surface waters data collected from the lakes in the Hiwassee River basin, 1994 - 1999.

Subbasin/			Dissolved				Secchi
Lake	Date	Station	oxygen	Temperature	pН	Conductivity	depth
01			-			•	•
Chatuge Lake	07/06/99	HIW000B	8.3	27.5	7.1	20	3.2
•	07/06/99	HIW000D	8.2	27.5	7.1	20	3.0
	07/06/99	HIW000F	8.3	27.4	7.1	20	4.2
	06/21/99	HIW000B	8.2	25.5	7.9	22	2.8
	06/21/99	HIW000D	8.1	26.9	7.2	22	3.2
	06/21/99	HIW000F	8.0	26.8	7.2	21	2.9
	08/31/94	HIW000B	8.1	26.4	7.3	17	1.4
	08/31/94	HIW000D	7.9	26.4	7.4	18	1.4
	08/31/94	HIW000F	7.5	26.3	7.6	17	2.3
02 Hiwassee Lake	07/28/99	HIW009A	8.2	30.3	8.1	26	2.9
	07/28/99	HIW009B	8.1	30.1	7.9	26	3.1
	07/28/99	HIW009D	8.2	29.4	8.1	24	2.7
	07/28/99	HIW009F	8.0	30.4	8.1	24	3.5
	07/28/99	HIW009G	7.7	29.9	7.8	24	3.4
	08/30/94	HIW009A	8.6	27.6	8.0	20	1.9
	08/30/94	HIW009B	8.3	28.0	7.9	20	1.7
	08/30/94	HIW009D	9.4	27.3	8.4	20	2.1
	08/30/94	HIW009F	9.0	27.4	8.4	20	1.7
	08/30/94	HIW009G	8.8	27.8	8.2	19	1.4
Apalachia Lake	07/28/99	HIW011A	6.6	17.6	6.5	24	3.0
L	07/28/99	HIW011C	8.5	28.8	7.3	23	3.3
	07/28/99	HIW012	9.1	27.3	7.9	22	3.3
	08/30/94	HIW011A	6.1	19.3	6.9	23	0.9
	08/30/94	HIW011C	8.3	26.9	6.5	21	2.3
	08/30/94	HIW012	8.0	27.6	6.6	20	3.1

Units of measure

Dissolved oxygen mg/l
Temperature °C
pH s.u.
Conductivity µmhos/cm
Secchi depth m

Appendix L3. Photic zone data collected from lakes in the Hiwassee River basin, 1994 -1999.

Subbasin/											Total	Suspended	
Lake	Date	Station	TP	TKN	NH_3	NO_x	TN	TON	TIN	Chl a	Solids	Solids	Turbidity
01													
Chatuge Lake	07/06/99	HIW000B	0.005	0.1	0.03	0.005	0.11	0.07	0.04	6	23	1.0	2.2
•	07/06/99	HIW000D	0.005	0.2	0.03	0.005	0.21	0.17	0.04	5	21	1.0	1.5
	07/06/99	HIW000F	0.005	0.2	0.03	0.005	0.21	0.17	0.04	6	19	1.0	1.5
	06/21/99	HIW000B	< 0.01	0.1	0.03	< 0.01	0.11	0.07	0.04	25	1	1.0	
	06/21/99		< 0.01	0.1		< 0.01	0.11	0.08	0.03	4	17	< 1	
	06/21/99	HIW000F	< 0.01	0.2	< 0.01	< 0.01	0.21	0.20	0.01	2	16	1.0	
	08/31/94	HIW000B	0.04	0.6	< 0.01	0.02	0.62	0.60	0.03	1	69	42.0	36.0
	08/31/94	HIW000D	0.08	0.3	0.02	0.03	0.33	0.28	0.05	2	62	38.0	29.0
	08/31/94	HIW000F	0.04	0.2	0.01	0.03	0.23	0.19	0.04	< 1	45	16.0	5.0
02													
Hiwassee Lake	07/28/99	HIW009A	< 0.01	0.3	0.08	0.03	0.33	0.22	0.11	5	40	1.0	1.4
	07/28/99	HIW009B	< 0.01	0.1	0.1	< 0.01	0.11	0.00	0.11	31	49	1.0	1.5
	07/28/99	HIW009D	< 0.01	0.4		< 0.01	0.41	0.18	0.23	22	45	1.0	1.0
	07/28/99	HIW009F	< 0.01	0.2	0.14	0.03	0.23	0.06	0.17	27	31	< 1	< 1.0
	07/28/99	HIW009G	< 0.01	0.3	0.19	< 0.01	0.31	0.11	0.20	21	33	2.0	< 1.0
	08/30/94	HIW009A	0.02	0.2	0.02	< 0.01	0.21	0.18	0.03	3	36	3.0	1.2
	08/30/94	HIW009B	0.02	0.3	0.06	< 0.01	0.31	0.24	0.07	3	34	4.0	2.6
		HIW009D	0.01	0.2		< 0.01	0.21	0.16	0.05	2	29	1.0	1.3
	08/30/94		0.02	0.2		< 0.01	0.21	0.15	0.06	2	29	1.0	1.3
	08/30/94	HIW009G	0.01	0.1	0.03	0.04	0.14	0.07	0.07	1	39	4.0	1.4
Apalachia Lake	07/28/99	HIW011A	< 0.01	0.3	0.13	0.18	0.48	0.17	0.31	4	35	< 1	1.0
	07/28/99	HIW011C	< 0.01	0.2	0.07	0.11	0.31	0.13	0.18	14	37	< 1	< 1.0
	07/28/99	HIW012	< 0.01	0.3	0.3	0.11	0.41	0.00	0.41	12	36	1.0	1.2
	08/30/94	HIW011A	0.02	0.2	< 0.01	0.2	0.40	0.20	0.21	< 1	32	2.0	2.6
	08/30/94	HIW011C	0.02	0.1	0.03	0.08	0.18	0.07	0.11	1	34	1.0	1.1
	08/30/94	HIW012	0.02	0.2	0.06	0.18	0.38	0.14	0.24	1	37	2.0	1.5

Abbreviations

total phosphorus
total Kjeldahl nitrogen
ammonia nitrogen
nitrate + nitrite nitrogen
total organic nitrogen
total inorganic nitrogen
chlorophyll a. TP TKN NH_3 No_x TON TIN

Chl a

Units of measure are mg/l, except for chlorophyll $\it a$ which is $\mu g/l$, and turbidity which is NTU.